Attachment 3

COMPARISON

OF

CALLAWAY PLANT

OFFSITE DOSE CALCULATIONS

FOR

ROUTINE EFFLUENTS

Performed by

Bechtel Power Corporation

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1.0 Introduction

The Offsite Dose Calculation Manual (ODCM) for Callaway presents the methodology for calculating setpoints and doses from liquid and gaseous effluents. To facilitate these calculations, simplify the tracking of previous quarterly and yearly releases, and quickly generate reports for submittal to the NRC, Union Electric Company (UE) has opted to computerize their ODCM. This report provides a comparison of results of test cases which were solved simultaneously by Bechtel Power Corporation and UE using hand calculations and the computer code, respectively.

2.0 Background

In Section 8.0 of Revision 1 to the ODCM, UE states that "computer codes are utilized to implement the ODCM methodologies. These calculational methods include the same general features as provided in the ODCM. These codes will be verified to produce results consistent with the ODCM methodologies." The NRC commented that Section 8 of the ODCM "states that the computer codes will be verified. After the codes are verified, provide a reference (individual or company, name, title of document, and date) in Section 8 to document the validation of the codes."

UE responded to this comment by retaining Bechtel Power Corporation to develop test cases and scenarios using Callaway site specific data, solve the test cases by hand using the ODCM methodologies, compare those results to the UE computer generated results, and prepare a report documenting the code verification. To that end, we have developed the test cases defined in Section 3.0, compared the hand calculated and computer generated results as described in Section 4.0. and are hereby submitting this report to document the verification.

During the course of our review, Union Electric was preparing Revision 2 of the ODCM. Any errors which we found in the ODCM text and tables were identified to Union Electric. The corrected values have been incorporated into Revision 2. Typographical errors identified in Revision 2 are listed in Table 18.

3.0 Description of Test Cases

Test cases were developed for both liquid and gaseous effluents. While developing the cases, the following points were considered:

a. The cases should test all of the major calculations covered by the ODCM (setpoints and offsite doses).

b. The scenarios should represent actual operating conditions as much as possible.

c. The cases should check each organ dose (total body, bone, liver, thyroid, kidney, lung, GI-LLI) and each dose pathway (ingestion, immersion, inhalation, ground plane, vegetation, grass-cow-milk, grass-goat-milk, meat).

d. Some test cases should evoke warning statements or "flags" when the Technical Specifications are exceeded.

3.1 Liquid Effluents

Four cases for release of liquid effluents were tested. They are described below in chronological order.

3.1.1 Steam Generator Blowdown

The first test case is designed to simulate continuous release of the steam generator blowdown surge tank from July 1 to September 30 (see Figure 1) at a rate of 270 gpm. Although the tank has a capacity of 1880 gallons, it is assumed for this calculation that there is ample influent to the tank to sustain a continuous release for a period of three months. The radioactive concentrations of the effluent stream are listed in Table 1. The allocation factor for this release is 1/2.

The steam generator blowdown discharge monitor O-BM-RE-52 continuously monitors the radioactivity at the blowdown discharge outlet. The sample point is located on the discharge of the blowdown pump. The high radioactivity alarm/trip setpoint initiates control room alarm annunciations and automatic isolation of the blowdown isolation valves and the blowdown discharge valve.

The steam generator blowdown water is diluted by the cooling tower blowdown flow, prior to entry into the Missouri River. The dilution flow rate is 10,000 gpm.

3.1.2 Liquid Radwaste

A liquid radwaste tank is released at a rate of 100 gpm on August 1 (see Figure 1). The volume of the tank is 2,000 gallons and the radioactive concentrations of the liquid radwaste are listed in Table 1. The allocation factor is 1/2 which indicates that discharge of the liquid radwaste runs concurrently with discharge of the steam generator blowdown water. The dilution flow rate is 10,000 gpm and is assumed to come from the cooling tower blowdown water.

A radiation setpoint is to be determined for the liquid radwaste discharge monitor O-HB-RE-18.

3.1.3 High TDS Collector Tank

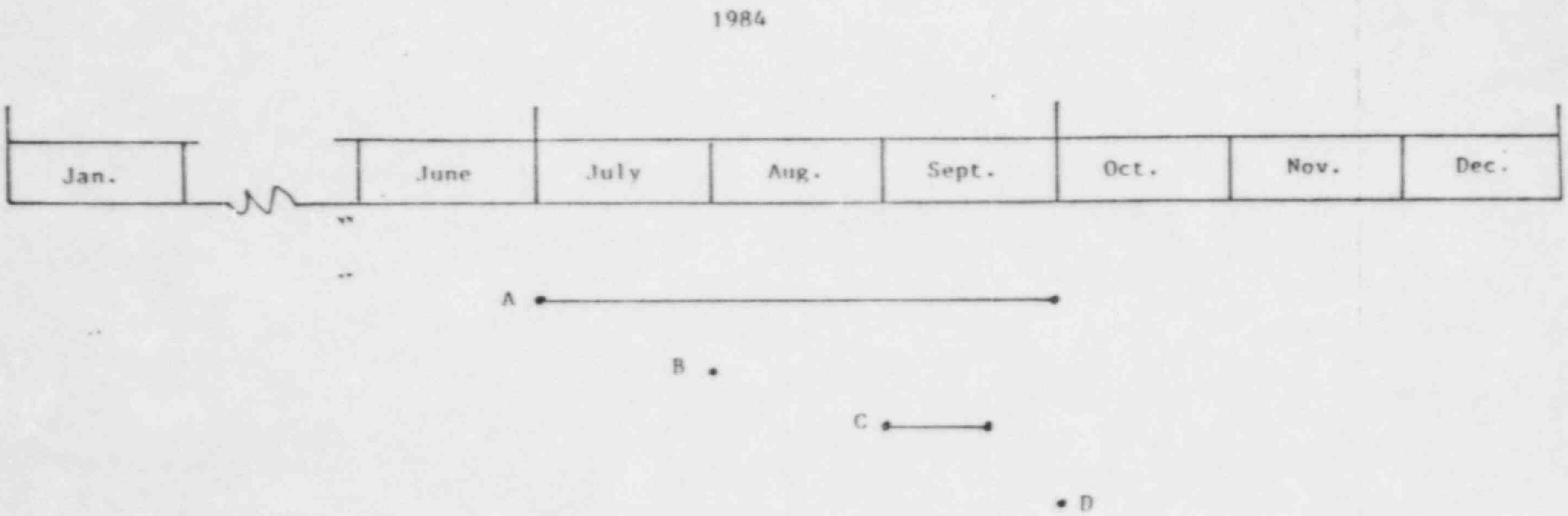
It is assumed that the high TDS collector tank must be released during the same calendar quarter (see Figure 1) as the steam generator blowdown surge tank. The high TDS collector tank contains 20,000 gallons and must be completely discharged every two days during the quarter at 35 gpm. This release can be simulated as a batch release of 920,000 gallons (20,000 gallons x 92 days ÷ 2 days). The release occurs between September 1 and 19. The isotopic concentrations of the liquid are listed in Table 1. The allocation factor for this release is 1/2 and the dilution flow rate is 10,000 gpm.

A setpoint is to be determined for the secondary liquid waste monitor 0-HF-RE-45.

3.1.4 Alarm Case

This is a fictitious case designed to test the "flag" subroutines built into the program. A tank containing 1,000 gallons of liquid radwaste composed of Cs-137 at 10^6 uCi/cc is to be discharged at 10 gpm on October 1 (see Figure 1). The allocation factor is 1/2 and the dilution flow rate is 5,000 gpm.

It was anticipated that all flags will be activated in the computer generated output.



Notes:

A. Steam generator blowdown release from July 1 to Sept. 30, 1984

B. LRW release on Aug. 1 for 20 minutes

C. High TDS release from Sept 1 to 19

D. Alarm case occurring on Oct. 1 for 100 minutes

Figure 1: Release Schedule for Liquid Effluents

Table 1

LIQUID EFFLUENT CONCENTRATIONS (uCi/cc)

Isotope	Steam Generator Blowdown Tank	Liquid Radwaste Tank	High TDS Tank	Alarm Case
H-3	3.50E-4	2.03E-3	-	-
C-14	-	1.20E-4	-	-
Cr-51	-	-	2.40E-7	-
Mn-54	-	-	6.43E-8	-
Fe-55	4.80E-9	1.85E-10	2.61E-7	-
Fe-59	-	-	1.73E-7	-
Co-58	-	-	2.41E-6	-
Co-60	5.40E-9	2.31E-10	2.94E-7	-
Ni-63	-	4.70E-4	-	-
Br-83	-	-	6.43E-8	-
Br-84	-	-	3.81E-9	-
Br-85	-	-	5.54E-12	-
Rb-86	-	-	1.96E-8	-
Rb-88	-	-	1.00E-8	-
Sr-89	2.50E-9	8.03E-11	1.22E-7	-
Sr-90	4.99E-11	2.41E-12	2.73E-9	-
Sr-91	-	-	5.46E-9	-
Y-90	-	-	2.25E-9	-
Y-91m	-	-	3.70E-9	-
Y-91	-	-	1.95E-8	-
Y-93	-	-	2.84E-10	-
Zr-95	-	-	1.20E-8	-
Nb-95	2.41E-10	5.56E-12	1.22E-8	-
Mo-99	-	-	6.35E-6	-
Ru-103	-	-	5.66E-9	-
Ru-106	-	-	1.29E-9	-
Te-125m	-	-	2.96E-9	-
Te-127m	-	-	3.10E-8	-
Te-127	-	-	3.39E-8	-
Te-129m	-	-	1.66E-7	-
Te-129	-	-	1.07E-7	-
Te-131m	-	-	3.61E-8	-
Te-131	-	-	6.70E-9	-
Te-132	6.16E-8	1.60E-9	8.81E-7	-
I-130	-	-	1.88E-7	-
I-131	1.12E-6	4.86E-8	3.18E-4	-
I-132	-	-	2.57E-6	-
I-133	1.52E-6	1.53E-8	5.97E-5	-
I-134	-	-	1.48E-7	-
I-135	-	-	8.77E-6	-
Cs-134	1.59E-7	3.00E-7	7.78E-6	-
Cs-136	8.28E-8	1.30E-7	2.65E-6	-
Cs-137	1.15E-7	2.17E-7	5.67E-6	1.00E-6
Ba-140	-	-	4.44E-8	-
La-140	-	-	4.71E-8	-
Ce-141	-	-	2.29E-8	-
Ce-143	-	-	8.23E-10	-
Ce-144	-	-	1.34E-8	-

Pr-143	-	-	9.55E-9	-
Pr-144	-	-	1.34E-8	-
Np-239	-	7.80E-4	-	-
Others	-	-	5.37E-6	-
Total	3.53E-4	3.40E-3	4.22E-4	1.00E+6

3.2 Gaseous Effluents

The unit vent continuously exhausts air from the auxiliary building, control building, fuel building, hot machine shop, and steam jet air ejector. In addition, the containment purges are exhausted via the unit vent. Each flow path is provided with HEPA filters and charcoal adsorbers, before the effluents exhaust to the unit vent. The unit vent radiation monitor 0-GT-RE-21 continuously monitors the gaseous effluents from the unit vent for particulate, halogen and gaseous radioactivity. The containment purge system monitors (0-GT-RE-22 and 0-GT-RE-33) continuously monitor the containment purge exhaust duct during purge operations for particulate, iodine and gaseous radioactivity.

The radwaste building ventilation effluent monitor 0-GH-RE-10 continuously monitors for particulate, halogen and gaseous radioactivity in the effluent duct downstream of the exhaust filters and fans. The flow path provides ventilation exhaust for all parts of the radwaste building and, also, a discharge path for the waste gas decay tank.

3.2.1 Gaseous Release Case 1

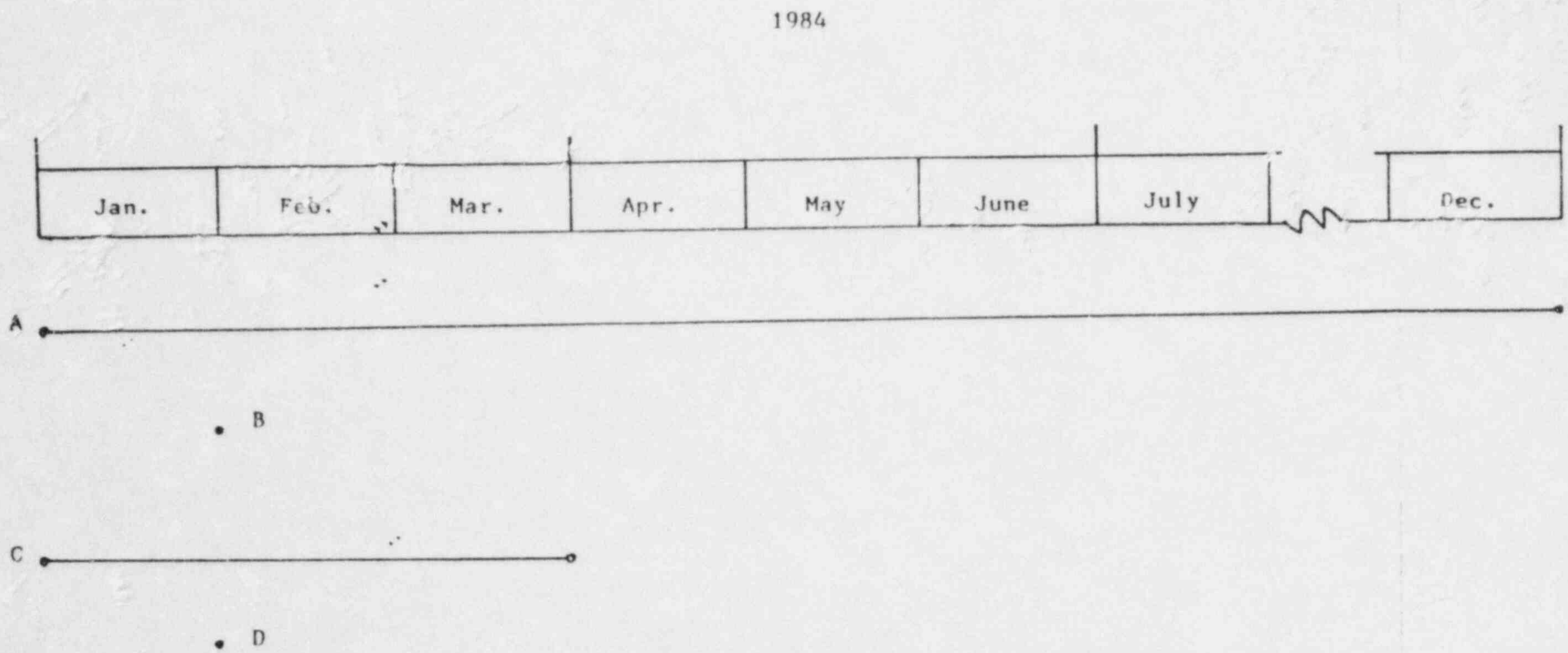
The unit vent release is continuous for the entire calendar year of 1984 and the containment purge is conducted on February 1 for 125 minutes (see Figure 2). The radwaste building ventilation exhaust is released for the first quarter of 1984 and the waste gas decay tank is released on February 1 for 600 minutes. The allocation factor is 1/2 for each of the above two flow paths (unit vent and radwaste building vent).

The principal parameters used for calculating radiation setpoints and doses at the site boundary are presented in Tables 2 and 3.

3.2.2 Gaseous Release Case 2

The unit vent release is continuous for the entire calendar year of 1985 and the containment purge is conducted on February 1 for 125 minutes (see Figure 3). The radwaste building vent is released for the entire calendar year of 1985. The allocation factor is 1/2 for each of the above two flow paths.

The principal parameters used for calculating radiation setpoints and doses at the site boundary are presented in Tables 2 and 3. The radioactivity from the containment purge represents approximately 1% of the core inventory of noble gases.



Notes:

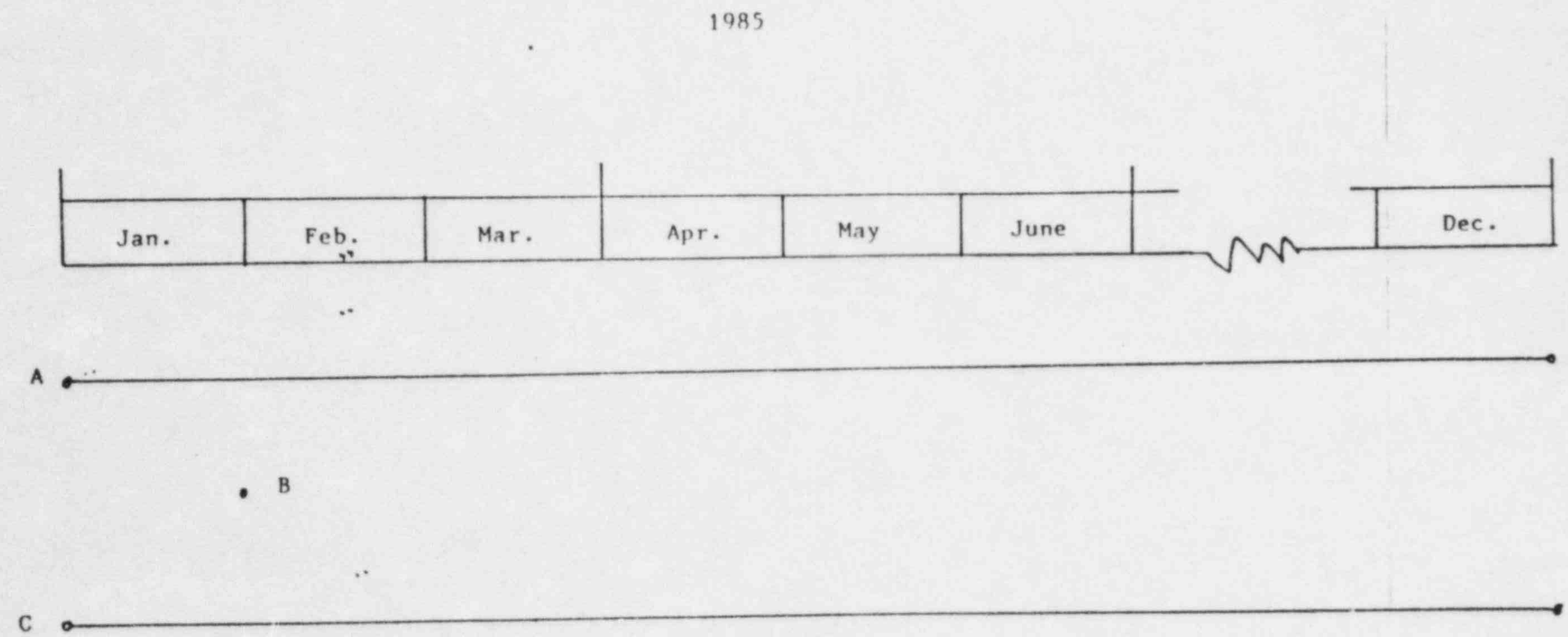
A. Unit vent continuous release from Jan. 1 to Dec. 31

B. Containment purge on Feb. 1 for 12 minutes

C. Radwaste building vent continuous release from Jan. 1 to March 31 for 91 days

D. Release from waste gas decay tank on Feb. 1 for 600 minutes

Figure 2: Release Schedule for Gaseous Effluents Case 1



Notes:

A. Unit vent continuous release from Jan. 1 to Dec. 31

B. Containment purge on Feb. 1 for 125 minutes

C. Radwaste building vent continuous release from
Jan. 1 to Dec. 31

Figure 3: Release Schedule for Gaseous Effluents Case 2

Table 2

Principal Parameters Used in Gaseous Effluent Calculations

Isotope	Concentration (uCi/cc) Gaseous Case 1	Gaseous Case 2	Volume, ft^3	Flow Rate, cfm
UNIT VENT			NA	62,000
H-3	5E-5	5E-5		
Xe-133	1E-5	1E-5		
CONTAINMENT PURGE			2.5E+6	20,000
Xe-133	1E-2	4E+1		
Ar-41	3E-4	-		
Kr-85	-	2E-1		
I-131	3E-5	-		
I-133	2E-5	-		
Co-60	3.5E-7	-		
Sr-90	1E-9	-		
Cs-137	1E-8	-		
Ce-144	-	1E-14		
RADWASTE BUILDING VENT			NA	12,000
Xe-133	1E-5	1E-5		
Ce-144	1E-14	1E-14		
WASTE GAS DECAY TANK			6.0E+2	1
Kr-85	5E+2	-		
Ce-144	1E-14	-		

Table 3

Highest Annual Average Atmospheric Dispersion Parameters

	Unit Vent	Radwaste Building Vent
A. Site Boundary		
X/Q (sec.m^{-3})	2.5E-7	9.7E-7
X/Q decayed (")	2.5E-7	9.7E-7
X/Q decayed/depleted(")	2.2E-7	8.6E-7
D/Q (m^{-2})	1.5E-9	4.0E-9
B. Nearest Residence		
X/Q (sec.m^{-3})	2.2E-7	8.4E-7
X/Q decayed (")	2.1E-7	8.4E-7
X/Q decayed/depleted (")	1.9E-7	7.2E-7
D/Q (m^{-2})	1.6E-9	4.1E-9

4.0 Comparison of Bechtel Hand Calculation and UE Computer Results

The comparison of our hand calculations and the Union Electric computer generated calculations yielded very favorable results. The doses by isotope for each organ and each pathway agree within a few percent. Values calculated by Bechtel and Union Electric are provided. A percent difference is also included which is defined as:

$$\frac{\text{Union Electric value} - \text{Bechtel value}}{\text{Bechtel value}}$$

This reflects the difference between the methodology presented in the Callaway ODCM and the methodology utilized by the computer code.

4.1 Liquid Effluents

Comparisons of the setpoint and dose calculations for each liquid release are provided in Tables 4 through 7. Table 8 tabulates the activity releases and doses for the third quarter of 1984, which includes the steam generator blowdown, liquid radwaste tank, and high TDS tank releases. The high TDS tank release is included in the activity and dose summary even though it is determined that the Maximum Permissible Concentration will be exceeded at the discharge point, and therefore the release would not be permitted.

Table 4

Comparison of Results for Steam Generator Blowdown

	Bechtel (Hand-calculation)	Union Electric (Computer-calculation)	Percent Difference
Pre-diluted conc. (uCi/cc)	3.53E-4	3.53E-4	0
Pre-diluted conc/MPC	5.40E+0	5.40+0	0
Max. permissible effluent flow rate, f_{max} (gpm)	772.63	750.11	-2.9
Adjustment factor, A	>1	No Flag	NA
Radiation monitor setpoint, c (uCi/ml)	8.77E-6	8.77E-6	0
Doses, D (mrem)			
Bone	6.10E-2	6.00E-2	-1.6
Liver	1.19E-1	1.17E-1	-1.7
Total Body	9.00E-2	8.85E-2	-1.7
Thyroid	6.36E-2	6.26E-2	-1.6
Kidney	4.14E-2	4.08E-2	-1.4
Lung	1.28E-2	1.26E-2	-1.6
GI-LLI	6.15E-3	6.04E-3	-1.8

Table 5

Comparison of Results for Liquid Radwaste Release

	Bechtel (Hand-calculation)	Union Electric (Computer-calculation)	Percent Difference
Pre-diluted conc. (uCi/cc)	3.40E-3	3.40E-3	0
Pre-diluted conc/MPC	8.70	24.51	See Note 1
Max. permissible effluent flow rate, f_{max} (gpm)	466	165.19	See Note 1
Adjustment factor, A	>1	No Flag	NA
Radiation monitor setpoint, c (uCi/ml)	3.64E-3	2.29E-3	See Note 1
Doses, D (mrem)			
Bone	6.88E-4	6.71E-4	-2.5
Liver	7.81E-5	7.62E-5	-2.4
Total Body	5.58E-5	5.43E-5	-2.7
Thyroid	2.80E-5	2.73E-5	-2.5
Kidney	3.22E-5	3.14E-5	-2.5
Lung	2.93E-5	2.85E-5	-2.7
GI-LLI	5.26E-5	5.13E-5	-2.5

Note:

1. The difference is due to Union Electric's assumption that C-14 and Ni-63 were gamma emitters. C-14 and Ni-63 happen to have high concentrations in this test case.

Table 6

Comparison of Results for High TDS Release

	Bechtel (Hand-calculation)	Union Electric (Computer-calculation)	Percent Difference
Pre-diluted conc. (uCi/cc)	4.22E-4	4.22E-4	0
Pre-diluted conc/MPC	1.12E+3	1.12E+3	0
Max. permissible effluent flow rate, f_{max} (gpm)	3.64	3.60	-1.1
Adjustment factor, A	A<1	Flag E	NA
Radiation monitor setpoint, c (uCi/ml)	4.39E-5	4.36E-5	-0.7
Dose, D (mrem)			
Bone	7.90E-2	7.74E-2	-2.0
Liver	1.52E-1	1.49E-1	-2.0
Total Body	1.15E-1	1.13E-1	-1.7
Thyroid	3.94E-1	3.86E-1	-2.0
Kidney	5.30E-2	5.22E-2	-1.5
Lung	1.63E-2	1.59E-2	-2.5
GI-LLI	5.15E-3	5.38E-3	4.5

Table 7

Comparison of Results for Alarm Case

	Bechtel (Hand-calculation)	Union Electric (Computer-calculation)	Percent Difference
Pre-diluted conc. (uCi/cc)	1E+6	1E+6	0
Pre-diluted conc/MPC	5E+10	5E+10	0
Max. permissible effluent flow rate, f_{max} (gpm)	4.06E-8	4.05E-8	-0.2
Adjustment factor, A	<1	Flag E	NA
Radiation monitor setpoint, c (uCi/ml)	4.06E-3	4.06E-3	0
Doses, D (mrem)			
Bone	1.42E7	1.39E7	-2.1
Liver	1.94E7	1.90E7	-2.1
Total Body	1.27E7	1.25E7	-1.6
Thyroid	No Data	No data	NA
Kidney	6.56E6	6.46E6	-1.5
Lung	2.18E6	2.15E6	-1.4
GI-LLI	3.74E5	3.68E5	-1.6

Table 8

Liquid Effluents Activity and Dose Summary

(Third Quarter 1984)

	Bechtel (Hand-calculation)	Union Electric (Computer-calculation)	Percent Difference
Activity Released (Ci)			
SG Blowdown	4.78E+1	4.78E+1	0
Liquid Radwaste Tank	2.57E-2	2.57E-2	0
High TDS Tank	1.47E+0	1.47E+0	0
Quarterly Doses (mrem)			
Bone	1.41E-1	1.38E-1	-2.1
Liver	2.71E-1	2.66E-1	-1.8
Total Body	2.05E-1	2.02E-1	-1.5
Thyroid	4.58E-1	4.49E-1	-2.0
Kidney	9.45E-2	9.30E-2	-1.6
Lung	2.91E-2	2.85E-2	-2.1
GI-LLI	1.13E-2	1.15E-2	-1.8

4.2 Gaseous Effluents

Two cases of gaseous releases are considered. The first case occurs within the year 1984 and consists of continuous and batch releases from both the unit vent and radwaste building vent. Tables 9 through 12 show comparisons of setpoints, dose rates, and doses for each individual release. Table 13 summarizes the 1984 annual releases for Case 1.

The second case occurs within 1985 and consists of the same continuous releases as the first case. Only one batch release is considered for Case 2. Tables 14 through 16 provide comparisons of setpoints, dose rates, and doses for each individual release. Table 17 summarizes the 1985 annual releases for Case 2.

Tables 9 through 12 and tables 14 through 16 give the hand calculated total body and skin monitor setpoints and the most restrictive setpoint calculated by the computer calculation. These setpoints are only applicable for that particular release path (e.g., containment purge) and do not consider concurrent releases (e.g., unit vent continuous release). Given below are the concurrent setpoints for Case 1 (1984) as calculated by hand.

	Setpoints (uCi/cc)	
Release	Total Body	Skin
Unit Vent (continuous plus containment purge)	0.0382	0.118
Radwaste Building Vent (continuous plus decay tank)	2.25	0.161

The computer output correctly identified the most restrictive setpoint to have a value of 0.0381 for the unit vent and 0.161 for the radwaste building vent.

For Case 2 (1985) the only concurrent release is the unit vent continuous and the containment purge. By hand calculation the concurrent setpoints for the unit vent are 0.0706 uCi/cc and 0.178 uCi/cc for the total body and skin, respectively. The computer output correctly identified the most restrictive setpoint to be 0.0707 uCi/cc.

Table 9

Comparison of Results for Unit Vent Continuous Release

(Case 1, First Quarter 1984)

	Bechtel (Hand-calculation)	Union Electric (Computer-calculation)	Percent Difference
Noble Gases			
Total Body Dose Rate (mrem/yr)	2.15E-2	2.15E-2	0
Skin Dose Rate (mrem/yr)	5.08E-2	5.10E-2	0.4
Total Body Setpoint (uCi/cc)	9.30E-2	9.30E-2	0
Skin Setpoint (uCi/cc)	2.36E-1	-	NA
Gamma Air Dose (mrad)	6.43E-3	6.44E-3	0.2
Beta Air Dose (mrad)	1.91E-2	1.91E-2	0
Total Body Dose (mrem)*	5.36E-3	5.36E-3	0
Skin Dose (mrem)*	1.27E-2	1.27E-2	0
Non-Noble Gas Isotopes			
Inhalation Dose Rate (mrem/yr)			
Bone	0.00E0	0.00E0	0
Liver	3.61E-1	3.62E-1	0.3
Total Body	3.61E-1	3.62E-1	0.3
Thyroid	3.61E-1	3.[illegible]E-1	0.3
Kidney	3.61E-1	3.62E-1	0.3
Lung	3.61E-1	3.62E-1	0.3
GI-LLI	3.61E-1	3.62E-1	0.3
Dose from All Pathways (mrem)			
Bone	0.00E0	0.00E0	0
Liver	7.01E-1	7.08E-1	1.0
Total Body	7.01E-1	7.08E-1	1.0
Thyroid	7.01E-1	7.08E-1	1.0
Kidney	7.01E-1	7.08E-1	1.0
Lung	7.01E-1	7.08E-1	1.0
GI-LLI	7.01E-1	7.08E-1	1.0
Skin	0.00E0	0.00E0	0

* Dose model not presented in ODCM; computer results presented doses.

Table 10

Comparison of Results for Radwaste Building Vent
Continuous Release

(Case 1, First Quarter 1984)

	Bechtel (Hand-calculation)	Union Electric (Computer-calculation)	Percent Difference
Noble Gases			
Total Body Dose Rate (mrem/yr)	1.61E-2	1.61E-2	0
Skin Dose Rate (mrem/yr)	3.81E-2	3.83E-2	0.5
Total Body Setpoint (uCi/cc)	1.24E-1	1.24E-1	0
Skin Setpoint (uCi/cc)	3.15E-1	-	NA
Gamma Air Dose (mrad)	4.83E-3	4.83E-3	0
Beta Air Dose (mrad)	1.44E-2	1.44E-2	0
Total Body Dose (mrem)*	4.02E-3	4.03E-3	0.2
Skin Dose (mrem)*	9.50E-3	9.55E-3	0.5

Non-Noble Isotopes

Inhalation Dose Rate (mrem/yr)
@ Site Boundary

Dose from All Pathways
(mrem)

Bone
Liver
Total Body
Thyroid
Kidney
Lung
GI-LLI

Note: For this case the hand calculation assumed no non-noble gas releases; therefore comparisons are not applicable.

* Dose model not presented in ODCM; computer results presented doses.

Table 11

Comparison of Results for Containment Purge

(Case 1, First Quarter 1984)

	Bechtel (Hand-calculation)	Union Electric (Computer-calculation)	Percent Difference
Noble Gases			
Total Body Dose Rate (mrem/yr)	1.32E+1	1.32E+1	0
Skin Dose Rate (mrem/yr)	2.55E+1	2.57E+1	0.8
Total Body Setpoint (uCi/cc)	1.56E-1	1.56E-1	0
Skin Setpoint (uCi/cc)	4.84E-1	-	NA
Gamma Air Dose (mrad)	3.54E-3	3.55E-3	0.3
Beta Air Dose (mrad)	6.44E-3	6.44E-3	0
Total Body Dose (mrem)*	3.13E-3	3.14E-3	0.3
Skin Dose (mrem)*	6.07E-3	6.11E-3	0.7
Non-Noble Gas Isotopes			
Inhalation Dose Rate (mrem/yr)			
Bone	3.92E0	3.91E0	-0.3
Liver	3.87E0	3.87E0	0
Total Body	2.05E0	2.05E0	0
Thyroid	1.17E3	1.17E3	0
Kidney	6.32E0	6.32E0	0
Lung	5.17E0	5.17E0	0
GI-LLI	4.75E-1	4.75-1	0
Dose from All Pathways (mrem)			
Bone	3.70E-1	3.70E-1	0
Liver	3.67E-1	3.67E-1	0
Total Body	2.22E-1	2.21E-1	-0.5
Thyroid	1.09E2	1.09E2	0
Kidney	5.76E-1	5.76E-1	0
Lung	3.11E-2	3.11E-2	0
GI-LLI	6.40E-2	6.37E-2	-0.5
Skin	3.47E-2	3.25E-2	-6.3

* Dose model not presented in ODCM; computer results presented doses.

Table 12

Comparison of Results for Gas Decay Tank Discharge

(Case 1, First Quarter, 1984)

	Bechtel (Hand-calculation)	Union Electric (Computer-calculation)	Percent Difference
Noble Gases			
Total Body Dose Rate (mrem/yr)	3.69E0	3.68E0	-0.3
Skin Dose Rate (mrem/yr)	3.11E2	3.11E2	0
Total Body Setpoint (uCi/cc)	2.71E4	-	NA
Skin Setpoint (uCi/cc)	1.93E3	1.93E3	0
Gamma Air Dose (mrad)	4.49E-3	4.49E-3	0
Beta Air Dose (mrad)	5.09E-1	5.09E-1	0
Total Body Dose (mrem)*	4.21E-3	4.21E-3	0
Skin Dose (mrem)*	3.55E-1	3.55E-1	0

Non-Noble Gas Isotopes

Inhalation Dose Rate (mrem/yr) @ Site Boundary

Dose from all Pathways (mrem)

Bone
Liver
Total Body
Thyroid
Kidney
Lung
GI-LLI

Note: For this case the hand calculation assumed no non-noble gas releases; therefore comparisons are not applicable.

* Dose model not presented in ODCM; computer results presented doses.

Table 13

Comparison of Results for Total Annual Releases

(Case 1, 1984)

	Bechtel (Hand-calculation)	Union Electric (Computer-calculation)	Percent Difference
Noble Gases			
Gamma Air Dose (mrad)	3.87E-2	3.88E-2	0.3
Beta Air Dose (mrad)	6.07E-1	6.07E-1	0
Total Body Dose (mrem)*	3.29E-2	3.29E-2	0
Skin Dose (mrem)*	4.22E-1	4.22E-2	0
Non-Noble Gas Isotopes			
Dose from All Pathways (mrem)			
Bone	3.70E-1	3.70E-1	0
Liver	3.19E0	3.22E0	0.9
Total Body	3.04E0	3.07E0	1.0
Thyroid	1.12E2	1.12E2	0
Kidney	3.40E0	3.43E0	0.9
Lung	2.85E0	2.88E0	1.1
GI-LLI	2.88E0	2.91E0	1.0
Skin	3.47E-2	3.47E-2	0

* Dose model not presented in ODCM; computer results presented doses.

Table 14

Comparison of Results for Unit Vent Continuous Release

(Case 2, First Quarter, 1985)

	Bechtel (Hand-calculation)	Union Electric (Computer-calculation)	Percent Difference
Noble Gases			
Total Body Dose Rate (mrem/yr)	2.15E-2	2.15E-2	0
Skin Dose Rate (mrem/yr)	5.08E-2	5.10E-2	0.4
Total Body Setpoint (uCi/cc)	9.30E-2	9.30E-2	0
Skin Setpoint uCi/cc)	2.36E-1	-	NA
Gamma Air Dose (mrad)	6.36E-3	6.37E-3	0.2
Beta Air Dose (mrad)	1.89E-?	1.89E-2	0
Total Body Dose (mrem)*	5.30E-3	5.30E-3	0
Skin Dose (mrem)*	1.26E-2	1.26E-3	0
Non-Noble Gas Isotopes			
Inhalation Dose Rate (mrem/yr)			
Bone	0.00E0	0.00E0	0
Liver	3.61E-1	3.62E-1	0.3
Total Body	3.61E-1	3.62E-1	0.3
Thyroid	3.61E-1	3.62E-1	0.3
Kidney	3.61E-1	3.62E-1	0.3
Lung	3.61E-1	3.62E-1	0.3
GI-LLI	3.61E-1	3.62E-1	0.3
Dose from All Pathways (mrem)			
Bone	0.00E0	0.00E0	0
Liver	6.93E-1	7.00E-1	1.0
Total Body	6.93E-1	7.00E-1	1.0
Thyroid	6.93E-1	7.00E-1	1.0
Kidney	6.93E-1	7.00E-1	1.0
Lung	6.93E-1	7.00E-1	1.0
GI-LLI	6.93E-1	7.00E-1	1.0
Skin	0.00E0	0.00E0	0

* Dose model not presented in ODCM; computer results presented doses.

Table 15

Comparison of Results for Radwaste Building Vent Continuous Release

(Case 2, First Quarter 1985)

	Bechtel (Hand-calculation)	Union Electric (Computer-calculation)	Percent Difference
Noble Gases			
Total Body Dose Rate (mrem/yr)	1.61E-2	1.61E-2	0
Skin Dose Rate (mrem/yr)	3.81E-2	3.83E-2	0.5
Total Body Setpoint (uCi/cc)	1.24E-1	1.24E-1	0
Skin Setpoint (uCi/cc)	3.15E-1	-	NA
Gamma Air Dose (mrad)	4.78E-3	4.78E-3	0
Beta Air Dose (mrad)	1.42E-2	1.42E-2	0
Total Body Dose (mrem)*	3.98E-3	3.98E-3	0
Skin Dose (mrem)*	9.40E-3	9.45E-3	0.5

Non-Noble Gas Isotopes

Inhalation Dose Rate (mrem/yr)
@ Site Boundary

Dose from All Pathways
(mrem)

Bone
Liver
Total Body
Thyroid
Kidney
Lung
GI-LLI

Note: For this case the hand calculation assumed no non-noble gas releases; therefore comparisons are not applicable.

* Dose model not presented in ODCM; computer results presented doses.

Table 16

Comparison of Results for Containment Purge

(Case 2, First Quarter 1985)

	Bechtel (Hand-calculation)	Union Electric (Computer-calculation)	Percent Difference
Noble Gases			
Total Body Dose Rate (mrem/yr)	2.78E4	2.77E4	-0.4
Skin Dose Rate (mrem/yr)	6.63E4	6.65E4	0.3
Total Body Setpoint (uCi/cc)	2.89E-1	2.90E-1	0.3
Skin Setpoint (uCi/cc)	7.28E-1	-	NA
Gamma Air Dose (mrad)	7.91E0	7.92E0	0.1
Beta Air Dose (mrad)	2.38E1	2.38E1	0
Total Body Dose (mrem)*	6.60E0	6.60E0	0
Skin Dose (mrem)*	1.57E1	1.58E1	0.6

Non-Noble Gas Isotopes

Inhalation Dose Rate (mrem/yr)
@ Site Boundary

Dose from All Pathways
(mrem)

Note: For this case the hand calculation assumed no non-noble gas releases; therefore comparisons are not applicable.

Bone
Liver
Total Body
Thyroid
Kidney
Lung
GI-LLI

* Dose model not presented in ODCM; computer results presented dose.

Table 17

Comparison of Results for Total Annual Releases

(Case 2, 1985)

	Bechtel (Hand-calculation)	Union Electric (Computer-calculation)	Percent Difference
Noble Gases			
Gamma Air Dose (mrad)	7.96E0	7.97E0	0.1
Beta Air Dose (mrad)	2.39E1	2.39E1	0
Total Body Dose (mrem)*	6.64E0	6.64E0	0
Skin Dose (mrem)*	1.58E1	1.59E1	0.6
Non-Noble Gas Isotopes			
Dose from All Pathways (mrem)			
Bone	0.00E0	2.76E-7**	NA
Liver	2.81E0	2.84E0	1.1
Total Body	2.81E0	2.84E0	1.1
Thyroid	2.81E0	2.84E0	1.1
Kidney	2.81E0	2.84E0	1.1
Lung	2.81E0	2.84E0	1.1
GI-LLI	2.81E0	2.84E0	1.1
Skin	0.00E0	Not Given	NA

* Dose model not presented in ODCM; computer results presented doses.

** Considers contribution by Ce-144 added to containment purge and radwaste vent releases.

5.0 Review of Other ODCM Information

The Callaway ODCM was thoroughly reviewed during the test case development and solution. Several items were found to be incorrect. These were identified to Union Electric during our review. The errors have been corrected and the revised values have been incorporated into Revision 2 (March 7, 1984) of the ODCM. Additional errors, mostly typographical, have been identified in Revision 2 and are listed in Table 18. UE has committed to notify NRC of these additional errors and corrections will be made in the next revision.

A summary of our review is provided below.

5.1 Check of Pathway Dose Factors (A_i, P_i, and R_i Values)

Table 1 of the ODCM lists ingestion dose commitment factors for the adult age group for consumption of fish exposed to liquid effluents. These factors were rigorously checked. Any discrepancies have been resolved and corrected values are incorporated into Revision 2 of the ODCM. Values which differed by less than five percent are deemed acceptable.

Table 3 of the ODCM lists dose factors for exposure to a semi-infinite cloud of noble gases. Again, these values were checked and errors corrected.

Tables 4 and 5 of the ODCM present dose factors for radionuclides other than noble gases for each pathway (inhalation, ground plane, vegetation, grass-cow-milk, grass-goat-milk, and meat). All discrepancies have been corrected. In particular, the grass-cow-milk and grass-goat-milk pathways were revised to apply to the child age group. This is consistent with all other pathways for gaseous effluents and provides the dose to the maximally exposed individual.

5.2 Check of Direct Radiation from Outside Storage Tanks

Section 4.2.3.1 of the ODCM was reviewed to ensure its technical accuracy. We found that the methodology as presented is acceptable. Typographical errors were pointed out to Union Electric. The revised section incorporates the corrections.

Table 18

Typographical Errors in ODCM Revision 2 (3/7/84)

		Should be
Page 51	Mu-54	Mn-54
	Mu-56	Mn-56
	fe-55	Fe-55
	fe-59	Fe-59
	Zn-60	Zn-69
	BR-83	Br-83
	BR-84	Br-84
	RB-89	Rb-89
	SR-91	Sr-91
Page 52	Rn-103	Ru-103
	Rn-105	Ru-105
Page 53, 7th nuclide	Cs-134	Cs-136
Page 54, P-32, Liver	4.37E10	4.37E9
Page 55	Rn-103	Ru-103
	Rn-105	Ru-105
Page 56, 2nd nuclide	I-131	I-132
I-132, Total Body	6.10E1	6.10E-1
Page 57, Zn-69, GI-LLI	9.11E4	9.11E-4
Page 58, I-130, Total Body	6.38ES	6.38E5
I-130, GI-LLI	5.79ES	5.79E5
Page 59, I-135, Kidney	1.70ES	1.70E5
Page 91, X/Q	(m^2/sec)	(sec/m^3)
X/Q Decayed/Undepleted	(m^2/sec)	(sec/m^3)
X/Q Decayed/Depleted	(m^2/sec)	(sec/m^3)

6.0 Conclusion

A detailed comparison of the results of the test cases has been performed by Bechtel. We conclude that the computer code utilized by Union Electric to calculate setpoints and doses from liquid and gaseous effluents is acceptable in that it produces results consistent with the ODCM methodologies. Our comparison shows that the parameters calculated by the Union Electric computer code are within a few percent of the values we calculated using the ODCM and hand calculations.

Union Electric has corrected all of the discrepancies we identified in the text and tables of the ODCM and has incorporated the changes into Revision 2. There are no outstanding issues to be resolved.